Field Testing of the Hewlett-Packard 7914 Winchester Disk aboard C.S.S. Baffin

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April 1984

Canadian Data Report of Hydrography and Ocean Sciences No. 18

Canada

85-5818/

Canadian Data Report Of Hydrography and Ocean Sciences

These reports provide a medium for the documentation and dissemination of data in a form directly useable by the scientific and engineering communities.

Generally, the reports will contain raw and/or analyzed data but will not contain interpretations of the data. Such compilations will commonly have been prepared in support of work related to the programs and interests of the Ocean Science and Surveys (OSS) sector of the Department of Fisheries and Oceans.

Data Reports are produced regionally but are numbered and indexed nationally. Requests for individual reports will be fulfilled by the issuing establishment listed on the front cover and title page. Out of stock reports will be supplied for a fee by commercial agents.

Regional and headquarters establishments of Ocean Science and Surveys ceased publication of their various report series as of December 1981. A complete listing of these publications and the last number issued under each title are published in the *Canadian Journal of Fisheries and Aquatic Sciences*, Volume 38: Index to Publications 1981. The current series began with Report Number 1 in January 1982.

Rapport statistique canadien sur l'hydrographie et les sciences océaniques

Ces rapports servent de véhicule pour la compilation et la diffusion des données sous une forme directement utilisable par les scientifiques et les techniciens.

En général, les rapports contiennent des données brutes ou analysées mais ne fournissent pas d'interprétations des données. Ces compilations sont préparées le plus souvent à l'appui de travaux reliés aux programmes et intérêts du service des Sciences et Levés océaniques (SLO) du ministère des Pêches et des Océans.

Les rapports statistiques sont produits à l'échelon régional mais sont numérotés et placés dans l'index à l'échelon national. Les demandes de rapports seront satisfaites par l'établissement auteur dont le nom figure sur la couverture et la page de titre. Les rapports épuisés seront fournis contre rétribution par des agents commerciaux.

Les établissements des Sciences et Levés océaniques dans les régions et à l'administration centrale ont cessé de publier leurs diverses séries de rapports depuis décembre 1981. Vous trouverez dans l'index des publications du volume 38 du *Journal canadien des sciences halieutiques et aquatiques*, la liste de ces publications ainsi que le dernier numéro paru dans chaque catégorie. La nouvelle série a commencé avec la publication du Rapport n° 1 en janvier 1982.

ABSTRACT

Varma, H.P. 1984. Field testing of the Hewlett-Packard 7914 Winchester disk aboard C.S.S. Baffin. Can.. Data Rep. Hydrogr. Ocean Sci. 18 : p.11 + iii

This report details the field tests of the H.P. 7914 disk drive conducted aboard C.S.S. Baffin from November 3 to 26, 1983. An H.P. 9836 computer was interfaced via the Hewlett Packard Interface Bus to the disk drive for the test. An H.P. printer was used to log any track errors or disk errors that occurred during the exercise period, and a pendulum device was used to monitor the motion of the ship. The results were portrayed on a Brush recorder. The disk survived a force of 1.35 times gravity in sway, 1.1 times gravity in heave, 0.7 times gravity in pitch, and equal to gravity in roll on November 26, 1983, possibly the worst weather of the cruise. Over the 23 day period of the operation, only one track error was recorded.

SOMMAIRE

Varma, H.P. 1984. Field testing of the Hewlett-Packard 7914 Winchester disk aboard C.S.S. Baffin. Can.. Data Rep. Hydrogr. Ocean Sci. 18: p.11 + iii

Ce rapport décrit des tests effectués sur l'unité de disque 7914 de Hewlett-Packard à bord du N.S.C. Baffin du 2 au 23 novembre 1983. L'unité de disque était alors reliée à un ordinateur H.P. 9836 au moyen d'un module d'interface de Hewlett-Packard. Une imprimante H.P. notait les erreurs de disque ou de piste durant cette période t'essai et un pendule d'enregistrement en continu Brush permettait d'illustrer les résultats. L'unité de disque fonctionna adéquatement lorsque soumis à une force équivalent 1.35 fois la force gravitationelle pour le mouvement latéral, 1.1 fois pour le soulèvement, 0.7 fois pour le torquage et égale à celle-ci pour le roulis le 26 novembre, probablement la journée des pires conditions météorologiques du voyage. Une seul erreur de piste fut enregistrée durant la période de 23 jours.

The Bedford Institute of Oceanography utilizes an H.P. 1000 system on most of its research and survey vessels. Disks now in use are the H.P. 7900 and 7906, both of which have successfully tolerated the rigours of the marine environment. With the advent of larger capacity Winchester disks, the probability of disk crashes seemed to be higher since the heads would be floating closer to the disk surface. This raised questions about the Winchester's capability to function properly on a sea-going vessel. Consequently, the tests described here were performed.

PROCEDURES

The C.S.S. Baffin ran lines from the southern coast of Nova Scotia to Georges Bank, well into the Gulf Stream. The disk was strapped to a large drafting table without shock mounts in order to maximize both the shock and vibration it would experience. An HP 9836 computer was interfaced via the H.P. Interface Bus to the disk drive (see Fig. 1). Test software was provided by Hewlett-Packard, and these programs were run all day throughout the cruise except for periodic shutdowns to run diagonistic software. These shutdowns were implemented during heavy seas when the ship underwent rolls of up to 25° and pitches of up to 15°. The motion of the ship was monitored by a pendulum device set up by D.McKeown and J. Dessureault (see Fig. 2). The software provided (program Write/Read) wrote 100 sectors onto the disk and then read the 100 sectors in a verification process. Any errors were reported on the H.P. printer. The other program "exercised" the disk by creating seeks (seeking between cylinders), which caused the head to move vigorously. This program was implemented when the ship was in rough seas. Shutdowns were also executed under these conditions in order for the head to return to the landing area of the disk.

Fig. 1. AN H.P. 9836 COMPUTER WITH PRINTER

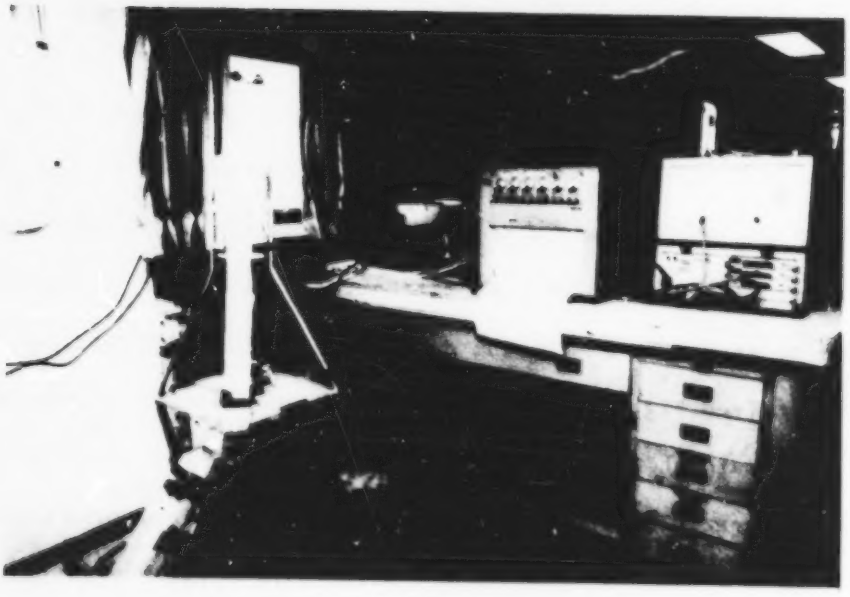

Fig. 2. PENDULUM DEVICE WITH BRUSH RECORDER

The disk drive was then immediately started up to see if it would come up to its optimum r.p.m. in spite of the ship's heave, roll, and vibration. The diagnostic programs were then run to show that the disk was operating at 100% efficiency. The Hewlett-Packard routines were implemented in order to check if the disk had any track errors. The controller circuitry in the Hewlett-Packard 7914 can "heal" disk damage to a certain extent. The controller sends the head over the whole disk surface when the disk starts up. In this process, it finds flawed sectors where data cannot be stored reliably, marks them so that future data will not be stored there, and moves endangered data to safer locations. This is done by writing endangered data on spare tracks. The H.P. 7914 has eight tracks that are used for effective track allocation and two that are used for maintenance tracks. In addition, it has two tracks reserved for future use.

RESULTS

One track error actually did occur on November 25, 1983. The weather was extremely bad - waves up to 6 m high and winds gusting to 70 km/h. The exerciser routine was run 255 times with a "full volume read only test" . On November 26, 1983, the last day of the cruise, the "exerciser" terminated and the printer output signified that an area of the disk was found where the media were damaged or faulty (no status bits were set). The Write/Read program was run and no status errors were printed. This implied that a bad track had occurred and had been reallocated to the spare tracks.

The reliability specified by most manufacturers is given as the M.T.B.F. (mean time between failure). This is an average of how long a hard drive is rated to run without breaking down. It is developed by

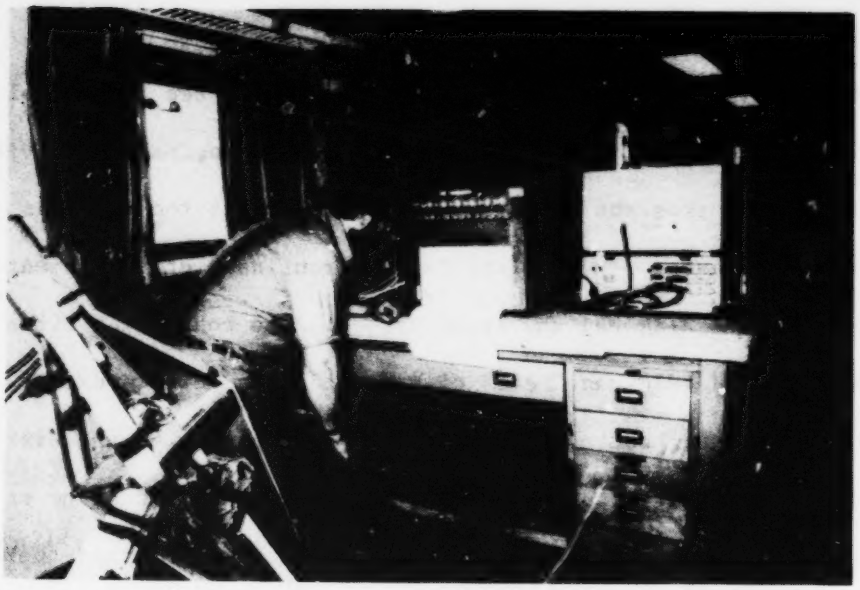

Fig. 4. PENDULUM DEVICE IN ACTION

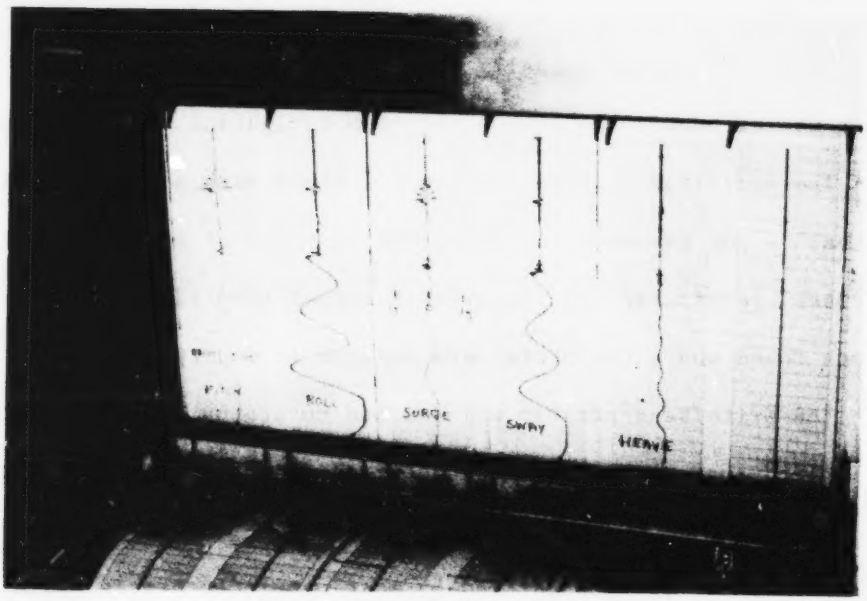

Fig. 5. BRUSH RECORDER DISPLAYING PITCH, ROLL, SURGE, SWAY AND HEAVE.

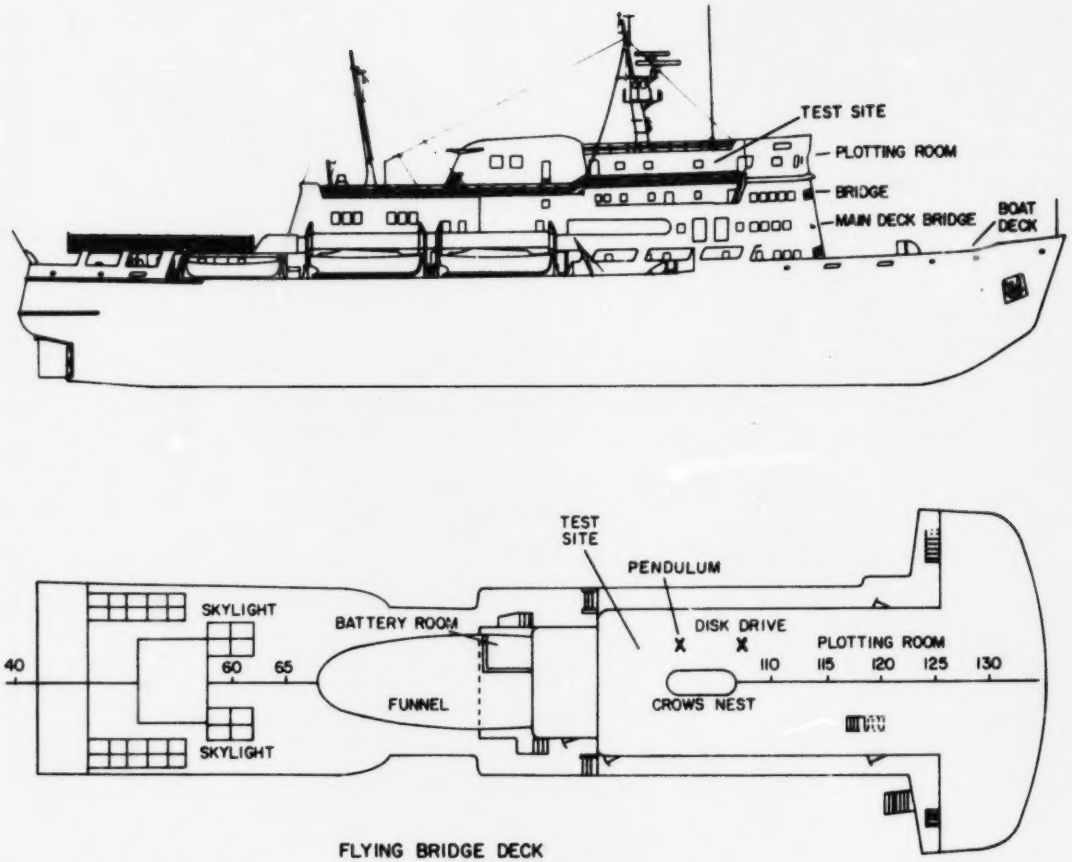
TEST SITE
PLOTTING ROOM
BRIDGE
MAIN DECK BRIDGE
BOAT DECK
TEST SITE
PENDULUM
SKYLIGHT
BATTERY ROOM
DISK DRIVE
PLOTTING ROOM
40
60
65
110
115
120
125
130
FUNNEL
CROWS NEST
SKYLIGHT
FLYING BRIDGE DECK

Fig. 3.

taking the time of failure of components in a finite period and statistically weighting these times according to standard well-developed formulae. The M.T.B.F. for the hard disk is typically more than 10,000 hours of operation. This would give the H.P.or 7914 more than a year of 24 hour-a-day operation between breakdowns. On the Baffin these tests were performed for a period of only 578 hours. However, the conditions were far from ideal: out of 23 days, only four were considered calm and on the others severe electrical storms occured, winds gusted 50 to 70 km/hand sea heights were up to 6 m, causing the ship to be pitched up to 15° and rolled up to 28°. The plotting room was maintained at a constant 22°C. The H.P. 7914 was situated in the aft end of the plotting room beside the base of the mast (see Fig. 3). This position subjected it to maximum motion and acceleration. These accelerations were monitored by a pendulum device, which gave readings of surge, sway, heave, pitch, and roll (see Fig. 4). (The roll accelerometer began to malfunction after 424 hours of operation).

The readings on the brush recorder were calibrated at 0.25 the force of gravity per division. The disk survived up to 1.35 times gravity (g) in sway, 1.1 times g in heave, 0.50 times g in surge, and 0.7 times g in pitch (Figs. 6, to 10). The graphs depict the absolute value of the accelerations aboard the vessel, sampled every 4 h during the cruise. The roll acceleration could not be determined accurately since the roll accelerometer periodically malfunctioned. Since the rolls on the Baffin were monitored at 28° and the pitch at 15°, it can be roughly estimated that the maximum roll acceleration was well above the force of gravity.

Due to weather conditions the ship was hove to on three separate occasions, and the Hewlett-Packard 7900 and 7906 disk drives were shut down on the general purpose computer to minimize the possibility of a disk

crash. It was under these conditions that the Hewlett-Packard 7914 was performing its exercise routines.

In conclusion, we have determined that the H.P. 7914 is a sturdy, reliable drive housed in one package (i.e., it has no external controller). It can be interfaced via the H.P. Interface Bus and has internal testing capabilities.

The H.P. 7914 disk has a storage capacity of 132 megabytes in comparison to the 5 and 20 megabyte H.P. 7900 and 7906 disks currently in use. This certainly will facilitate managing and processing the increasing digital data we collect.

There are several other conditions under which the disk should also be checked: its performance on a small vessel (i.e. C.S.S. Maxwell), its ability to function on a vessel traversing ice-infested waters, and also the effect on it of airguns firing on a cruise. These conditions have plagued various instruments aboard ships - for example, vibration loosened circuit boards out of their sockets on Maxwell during heavy seas. Lastly, although the drive was subjected to tests under extreme conditions, it was only for a period of 578 hours. It would be interesting to see its performance over a longer period of time on a smaller vessel.

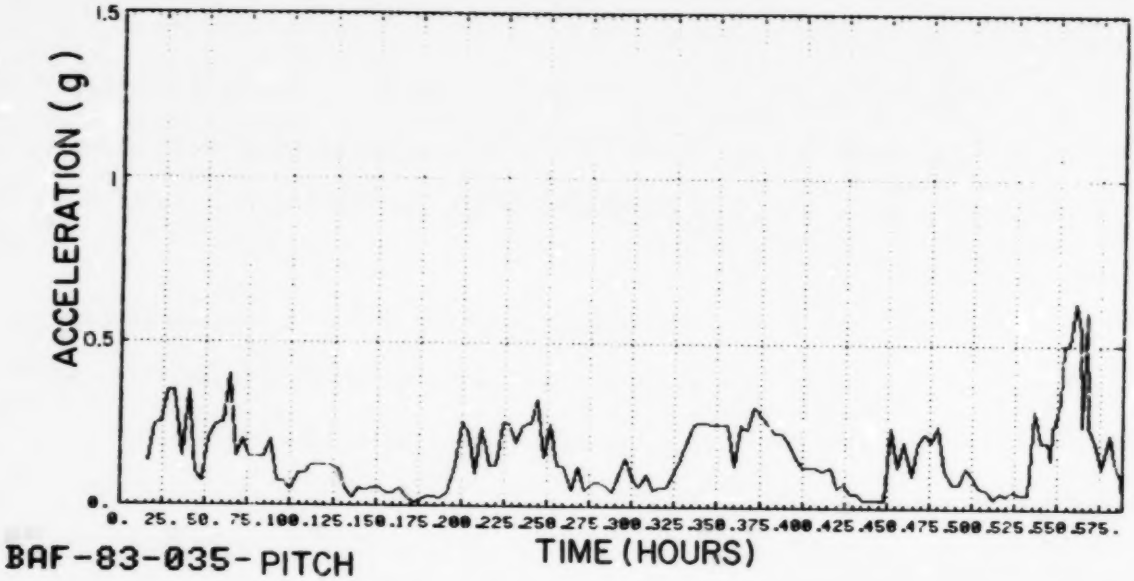
ACCELERATION (g)
1.5
1
0.5
0.
0. 25. 50. 75. 100. 125. 150. 175. 200. 225. 250. 275. 300. 325. 350. 375. 400. 425. 450. 475. 500. 525. 550. 575.
TIME (HOURS)
BAF-83-035- PITCH

Fig. 6.

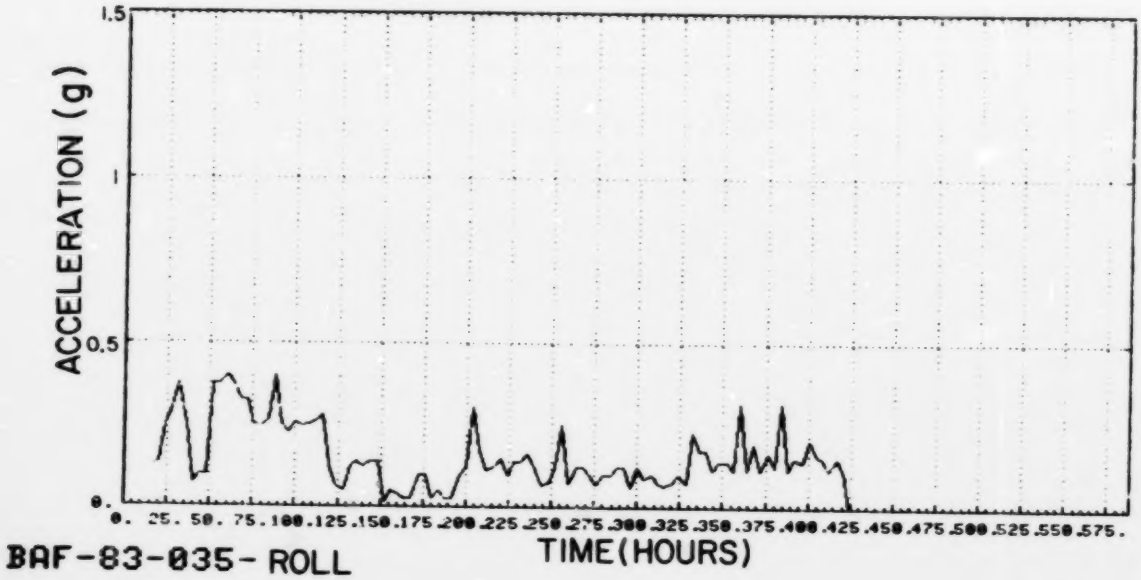
ACCELERATION (g)
1.5
1
0.5
0.
0. 25. 50. 75. 100. 125. 150. 175. 200. 225. 250. 275. 300. 325. 350. 375. 400. 425. 450. 475. 500. 525. 550. 575.
TIME(HOURS)
BAF-83-035- ROLL

Fig. 7.

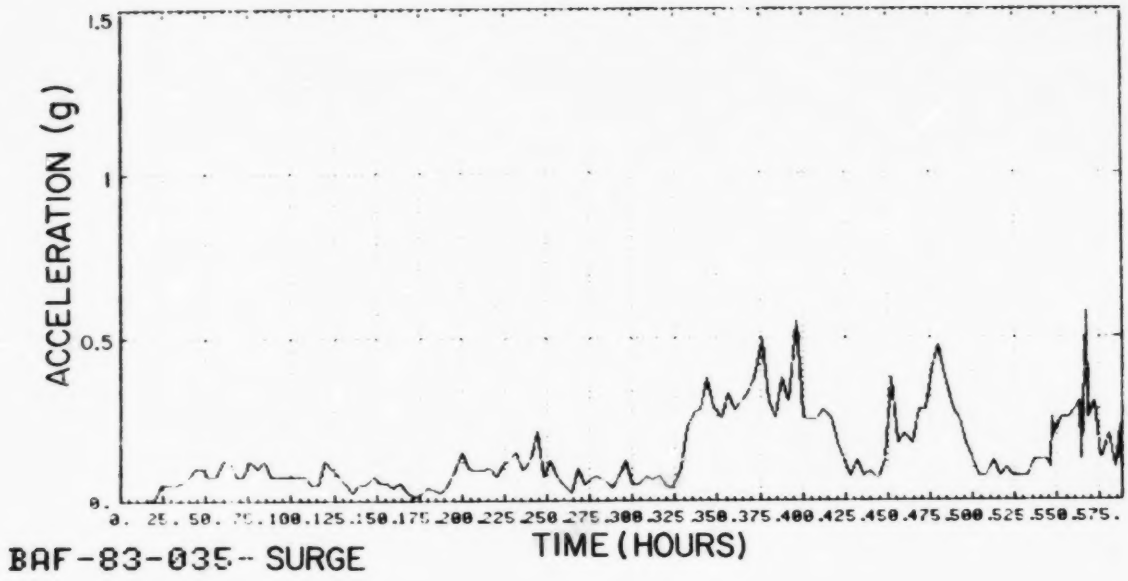
1.5
1
0.5
0.
ACCELERATION (g)
0. 25. 50. 75. 100. 125. 150. 175. 200. 225. 250. 275. 300. 325. 350. 375. 400. 425. 450. 475. 500. 525. 550. 575.
TIME (HOURS)
BAF-83-035- SURGE

Fig. 8.

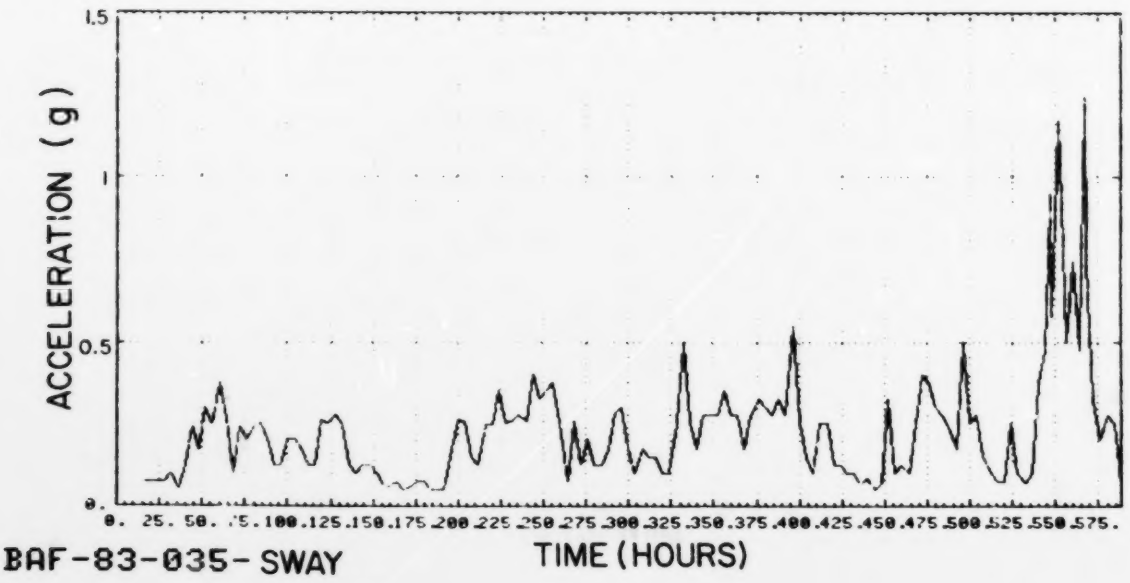
1.5
1
0.5
0.
ACCELERATION (g)
0. 25. 50. 75. 100. 125. 150. 175. 200. 225. 250. 275. 300. 325. 350. 375. 400. 425. 450. 475. 500. 525. 550. 575.
TIME (HOURS)
BAF-83-035- SWAY

Fig. 9.

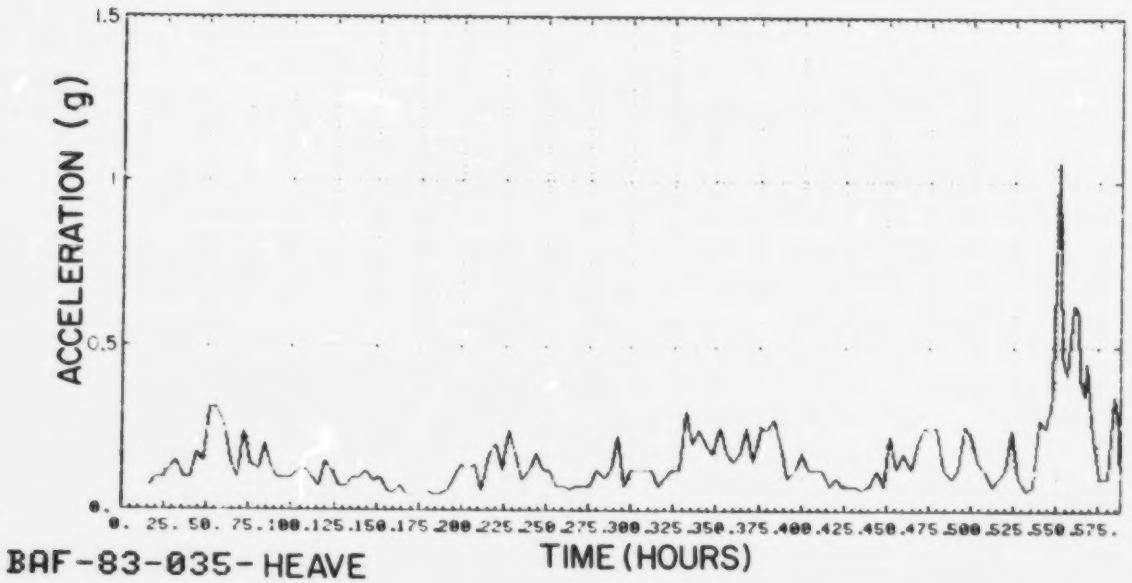
1.5
1
0.5
0.
ACCELERATION (g)
0. 25. 50. 75. 100. 125. 150. 175. 200. 225. 250. 275. 300. 325. 350. 375. 400. 425. 450. 475. 500. 525. 550. 575.
TIME (HOURS)
BAF-83-035- HEAVE

Fig. 10.

APPENDIX A

SPECIFICATIONS OF THE H.P. 7914

The H.P. 7914A, a mass storage subsystem offering 132 megabytes of Winchester disk storage, is rated to: withstand 11 ms half-wave sine-shock with a peak amplitude of twice the force of gravity in any direction during operation; withstand a vibration of up to 0.25 the force of gravity in any direction; operate reliably between 10 and 40°c; withstand humidities of 20% to 80% with a maximum of 0.015 lb. of water per pound of dry non-condensing air. These rated specifications were tested during Baffin cruise 83-035.

Disc Performance	
Average Controller throughput time:	9.4 ms
Average seek time	27.4 ms
Average delay	8.3 ms
Average time to transfer 1 kilobyte	1.0 ms
Total average transaction time (excluding System Overhead)	46.4 ms
Maximum disc transactions per second, for 1 kilobyte transfer less overhead.	21.5 ms

Overall Characteristics:

Heat dissipation 925 Watts (3157 Btu/hr)
Electromagnetic emissions
Radiated and conducted interfaces
7914TD - for U.S.A. designed to meet FCC docket 20780 for Class A Computing devices

7914TD - For European designed to meet VDE0871 for Level A computing devices.

FTZ licensed on same H.P. systems.

Dimensions

Height = 311 mm (12.25 in.)

Front Panel Width = 482 mm (19.0 in.)

Width (Behind Front Panel) = 451 mm (17.75 in.)

Dimensions (cont'd)

Depth (Behind Front Panel) = 705 mm (27.8 in)

Depth (Overall) = 752 mm (29.6 in)

Net weight = 67.2 kg (148 lb)

APPENDIX B

MAINTENANCE IN THE FIELD

All the control and Read/Write interface boards are easily accessible,which facilitates direct board replacement. Serviceability of the H.P. 7914 is enhanced by an extensive self-diagnostic capability resident in the controller. Troubleshooting of intermittent failures is facilitated by an error logging capability, which allows trained service personnel to detect failure patterns over time. In addition, an error-correction integrated-circuit corrects data errors in real time, without any degradation in the data transfer rates.

At sea, the hardest item to service is the sealed drive unit. There are two chief concerns: (a) the user must worry about the possibility of a fixed-disk failure. If the disk crashes at sea, it can be replaced only by a trained technician working in a sterile environment. Most of the disk problems we encounter are due to soft or hard disk crashes that ruin either the heads or the disk surfaces. It is very seldom that electronic-card failures are encountered. Therefore, it is imperative to have backup Winchester drives on long voyages. (b) the sealed disk would not have as high a likelihood of suffering a soft or hard crash due to a dusty or salty environment as would an ordinary disk. Nevertheless, Hewlett-Packard is also marketing a repair service kit with an enclosed disk to facilitate repairs in remote environments.

APPENDIX C

A DISSERTATION ON THE WINCHESTER DISK

Since 1973, the Winchester drive has been the chief hard disk in use. This was the code name of the 1973 I.B.M. project that yielded the first commercial disk drive. The project name was coined from the fact that the first drive came in a 30+30 megabyte combination of two disks: one was a fixed backup for the first. This reminded someone of a Winchester 30,30 repeating rifle.

The disk drive taken aboard C.S.S. Baffin was not of the above vintage; rather it was a single disk system, purporting 132 megabyte storage, with a streaming cartridge system incorporated into the unit. The disk was theHewlett-Packard 7914 R.

When viewing the top of the Winchester, one does not see much. One shielded box houses the power supply which transfers the line current into the low voltage which the drive requires. This supply is enclosed to reduce shock hazard and to shield the rest of the system from stray currents. Nearby are printed circuit boards which consist of the drive controller (the intelligence of the drive) and the disk motor controller (the heart of the drive). The disk itself, with its associated read/write head mechanisms is sealed in another housing.

The streaming cartridge system of the disk requires two tapes to back up the entire disk. These systems are called "streaming tape drives", or simply "streamers" because they read data in a continuous stream from a disk. Since these streaming tape drives lack block identifiers, data are stored on the tape in one large chunk. The computer cannot go to the tape drive and find a specific piece of information. It is, therefore, necessary to reload the data onto the disk and instruct the disk controller

to locate the information one is looking for. Since the streamer will be used for archiving and backup, the relative inaccessibility is not a real problem. For selective backup there are software techniques (i.e. "Reader/Saver") which will copy specific files onto magnetic tape. These types of backup procedures will probably be used more often in lieu of the streaming option due to the time (two hours) involved to back-up an entire disk. Not only will this capability speed up the backup procedure, but it will also organize the files which in turn will facilitate recovery from magnetic tapes.

In previous years, when using H.P. 7900 and 7906 drives, one had to wait for the computer and disk driver to communicate with each other and to transfer data back and forth. One also had to handle the disk carefully to prevent damage especially since one often shuffled them in and out of the respective disk drives, going from one set of data to another. More importantly, one had to break large data files into separate disks because one disk could not handle all the information that had to be manipulated, especially in the realm of bathymetry where it is possible to collect up to half a million soundings in one year alone. With the advent of the sweep system, this volume will be increased substantially. The storage capacity of the Hewlett-Packard 7914 R gives the user the capability to handle a great amount of data with speed and efficiency which opens up new vistas for such applications as large inventory systems, data base management systems, and data analysis applications.

Winchester hard disk assemblies are put together in sterile and dirt free surroundings where even microscopic dust particles cannot get on the disk surface. The air gets into the disk's sealed housing via a special filter that maintains the clean room conditions inside the disk

head assembly. This practically dirt free environment is required to keep the drive from damaging itself in operation. The Winchester drive uses a Read/Write head to record data onto the particle coating by selectively magnetizing these particles. A reversal of this process lets the head read the data which the drive then amplifies and sends to the computer. The physical phenomenon which is the basis of these operations is called magnetic induction. It is an inherently weak process, thus the smaller the distance involved between head and platter, the better it works. The platter itself is rotating at approximately 3600 r.p.m. To allow these speeds, the head must be lifted up off the surface of the disk a miniscule amount. To move the head this microscopic distance above the disk surface, the head is carried on a little wing. As the disk spins, friction between the disk surface and the air around it drags the air along with the disk. The air, passing over the wing on which the head is mounted, causes the aerodynamic lift, making the head actually fly over the disk. During Read/Write seek operation, the Winchester head flies over the surface on an air cushion supported by carefully balanced aerodynamic forces. As the disk starts or stops, the head takes off or lands in a silicone lubricated landing area. When the disk is not spinning, the head rests on, and actually contacts the landing zone on the disk. An ultra-fine coating is used to fill in the minute valleys in the coasting for aerodynamic perfection. The problems that plague Winchester disks, and the reasons why they are assembled in a clean environment is that, at the speeds and clearances involved, a speck of dust would smack the Read/Write head like a pebble hitting the windshield of a car moving at 100 m.p.h. This would cause minute damage to the head. A series of these soft crashes would ultimately lead to a hard disk crash. Since Winchester disks operate in a

sealed environment the sealed design makes the disk almost indifferent to the external environment. Therefore it is virtually impossible for contamination to get into the sealed compartment and these disks do not need to be cleaned.

Winchesters do not like thermal extremes. If the temperature inside the drive housing gets significantly high, the heat can damage the drive's electronics. Therefore, all Winchesters have heat sink units or large masses of metal that transfer heat to the ambient air.